Unilateral spatial neglect is one of the most common symptoms of stroke. It has important implications for occupational therapy because of its clinical manifestations, which include problems with activities of daily living, mobility, and reading. This article reviews neurophysiological theories pertaining to unilateral spatial neglect and focuses on two new treatment approaches with potential application to occupational therapy practice. Both approaches—constraint-induced therapy and partial visual occlusion—involves restrain of the less affected side. These approaches are discussed in the context of current neurophysiological theories and the application to occupational therapy treatment for neglect.

leads to poor comprehension of written materials (Kinsella & Ford, 1985). In general, the distorted perception of the world resulting from unilateral spatial neglect can contribute to confusion in daily life.

Denes, Semenza, Stoppa, and Lis (1982) assessed 48 patients with stroke (24 with right hemisphere lesions, 24 with left hemisphere lesions) on admission to a rehabilitation facility and again 6 months after admission. Their evaluations focused on severity of impairment (i.e., motor, tactile, and visual deficits), activities of daily living (ADL) status, neuropsychological factors (including neglect and language), and emotional reactions. The researchers found that patients with right hemisphere lesions often had a lesser degree of independence after 6 months than patients with left hemisphere lesions.

Denes et al.’s (1982) data were submitted to two analyses of covariance that respectively compared motor and ADL improvements between the two groups (i.e., patients with right and patients with left hemisphere lesions). This analysis was done after partialling out the concomitant variables (severity of initial sensorimotor deficit, unilateral spatial agnosia, anasognosia, score on a language test, score on a neuropsychological test). Regression coefficients were calculated after the two analyses were performed. The only significant value ($p = .05$) was related to the effect of unilateral spatial neglect on ADL improvements. The researchers concluded that the presence of unilateral spatial neglect seemed to be the most important factor in delaying ADL recovery.

The present article reviews the literature on unilateral spatial neglect and describes new treatment approaches with potential application to occupational therapy treatment of this phenomenon. The first section discusses the neurophysiological basis of neglect; the second section reviews new approaches for treatment. The treatment options for neglect are discussed in the context of the current health care climate, which emphasizes shorter stays and functional outcomes.

Most studies regarding neglect base their findings on the use of neuropsychological measurements to assess changes. The most commonly used neuropsychological tests, as discussed by Okkema (1993), are as follows: The Schenkenberg Line Bisection Test (Schenkenberg, Bradford, & Ajax, 1980) consists of a series of horizontal lines on a page. The subject is asked to mark the center of each line, and scores are calculated by the mark’s percentage of deviation from midline. Albert’s Test (Albert, 1973) requires the subject to cross out 41 randomly oriented lines arranged in roughly six rows. The test is scored by the number of lines missed. With Diller’s Test (Diller, Ben-Yishay, & Gerstman, 1974), the subject is asked to look at a page with six rows of 52 typed letters and to mark through all the letters C and E. The score is based on time and number of errors. Drawing and copying tasks are also used but require more subjective methods of scoring. Persons with unilateral spatial neglect generally tend to omit or neglect details on the right or left side of the drawing or copying activity. They also tend to draw everything on one side of the page.

It is often reported that most patients who present with neglect shortly after a stroke will have little or no evidence of neglect at 3 months poststroke (D’Esposito, 1997). Most of these reports are based on neuropsychological measures. However, researchers who have included ADL assessments in their outcome measures have had contradictory findings. Kinsella and Ford (1985) assessed 31 patients with stroke (17 with left hemisphere damage, 14 with right hemisphere damage) at 4 weeks, 8 weeks, 12 weeks, and 18 months poststroke. They administered ADL and neuropsychological neglect assessments. The neuropsychological manifestations of neglect had significantly diminished in all cases at the 18-month follow-up. However, the patients who presented with neglect at the 4-week assessment achieved significantly poorer functional outcomes at the final assessment. The researchers postulated that the apparent recovery from neglect often noted in the literature was an artifact of the assessment methods. Lin (1996) cited several other studies that implicated a residual rightward orientation bias in poor functional outcomes. This rightward orientation bias is described as a contributing factor to neglect in neuropsychology literature (Kinsbourne, 1987).

**Neurophysiological Basis of Neglect**

The neurophysiological mechanisms underlying unilateral spatial neglect are not fully understood. Current theories favor the role of attentional mechanisms.

**Attention–Arousal Theory**

The attention–arousal theory (Heilman & Valenstein, 1979) states that unilateral spatial neglect may be caused by damage to the structures responsible for arousal and transmission of sensory information to the cortex. This damage is believed to lead to decreased attention to the side contralateral to the lesion, which clinically manifests as unilateral spatial neglect. Proponents of this theory propose that unilateral spatial neglect results from a lesion anywhere in the cortico-limbic-reticular network (Heilman et al., 1993). The central structure in this network is the mesencephalic reticular formation (MRF), which is associated with behavioral arousal. Also present in this network is the nucleus reticularis thalami (NRT), which inhibits relay of sensory information from the thalamus to the cortex (Cermak, Trombly, Hauser, & Tiernan, 1991). The MRF normally inhibits the NRT, allowing sensory information to be transmitted to the cortex. Heilman et al. (1993) proposed that damage to the MRF would cause disinhibition to the inhibitory NRT, thus decreasing transmission of sen-
sory information to the cortex. Neglect theoretically could be caused by the cortex not receiving adequate sensory information from the subcortical structures. Another proposed explanation is that the damaged MRF cannot adequately prepare (arouse) the cortex for sensory processing.

The inferior parietal lobe is part of the MRF network and is the most frequent site of lesion in persons with unilateral spatial neglect (Cooke, 1992; Hommel et al., 1990). Goldberg and Robinson (1977) studied the responses of neurons in the inferior parietal lobes of monkeys to determine the effect of visual properties of light stimuli as well as the effect of behavioral considerations on activation of the neurons of the inferior parietal lobe. They found that these neurons responded to light anywhere in a large visual field. The response of many of these neurons was found to be enhanced when the stimulus required a behavioral act, such as hand or eye movement. This enhanced response could be due to the roles of the limbic and frontal lobes in determining stimulus significance in terms of directing attention (Heilman et al., 1993). The limbic system may mediate biological motivational states, whereas the frontal lobes might provide input about needs related to an individual's personal goals (Heilman et al., 1993). The inferior parietal lobe has connections to the frontal lobe and the limbic system, both critical for attention (Heilman et al., 1993).

Premotor activation theory (Lin, 1996) suggests that motor preparation and attention are closely linked. Robertson and North (1992, 1993) have shown that active movement of the affected extremity, especially in the affected hemispace, could reduce the manifestations of visual spatial neglect. Herman (1992) discussed the concept of spatial compatibility. She stated that a person with left spatial neglect is likely to commit fewer errors when using the left hand in the left hemispace. It is proposed that activation of the motor system in a certain hemispace would lead to recruitment of attention to that hemispace (Robertson & North, 1993).

Hemispheric Specialization

Another theory related to attention focuses on hemispheric specialization. Some authors have proposed that the right hemisphere is specialized for attention to left and right hemispace, whereas the left hemisphere only attends to the right hemispace (Robertson, Tegner, Tham, Lo, & Nimmo-Smith, 1995). If a person sustains damage to the left hemispace, the right hemisphere theoretically can compensate by attending to both sides of space. However, if a person has right hemisphere damage, the left hemisphere is only able to attend to the right hemispace. Positron emission tomography provides some evidence that the right hemisphere plays a dominant role in sustaining attention (Robertson et al., 1995). Norepinephrine may be the main neurotransmitter involved in sustaining attention and has been shown to have a right hemisphere bias (Robertson et al.). This finding lends some credibility to the hemispheric specialization theory.

Heilman and Van den Abell (1979) tested the effect of left-sided and right-sided visual stimuli on the reaction times of 24 healthy persons. They found that stimuli to the right visual space produced slower reaction times than stimuli to the left. The researchers proposed that their findings could be partially explained by the hypothesis that the right hemisphere dominates activation of attention mechanisms. This right hemisphere dominance of attention would account for faster reaction times in the left visual space, which is controlled by the right hemisphere.

Disengagement Theory

The disengagement theory is another explanation for neglect as it relates to attention. In a single-subject case study, Di Pellegrino (1995) reported on a subject with left neglect whose test results indicated difficulty in disengaging his attention from right-sided stimuli. The subject was tested on three conditions of a clock-drawing task. He drew a clock-face with left-sided numbers transposed to the right side of the dial when asked to draw a clock spontaneously and when the sequence was provided by the researcher. However, he incorrectly placed the numbers when drawing them on a separate dial. Di Pellegrino postulated that the subject's decreased attention to left-sided visual stimuli might have been caused by his inability to stop attending to objects in the right hemispace.

Posner, Walker, Friedrich, and Rafal (1984) studied visual attention shifting of 12 patients with various brain injuries. They divided the act of shifting attention into three operations: disengagement from the current focus, moving attention to the next target, and focusing attention on that target. The researchers found that the patients with parietal lesions and unilateral visual neglect had difficulty disengaging from stimuli on the side of the lesion when presented with visual stimuli in various locations.

Mark, Kooistra, and Heilman (1988) used a line-cancellation task to study the disengagement theory. Ten patients with right hemisphere lesions were asked to cancel a series of lines in two different ways: (a) by drawing over each line with a black pen and (b) by erasing a series of lines. The patients consistently performed better on the erasing task. Fifty percent of the patients showed no measurable neglect when erasing lines. The authors argued that their findings supported the theory that neglect is influenced by the presence of stimuli in the nonneglected hemispace. The fact that some patients had incomplete reduction of neglect symptoms when erasing lines suggests that the disengagement theory only partially explains the neglect phenomenon.

The disengagement theory bears relation to extinction phenomenon, which is a manifestation of the sensory-rep-
resentational aspect of hemispatial neglect (Mesulam, 1998). This phenomenon is present when persons who have no difficulty detecting unilateral stimuli on either side experience bilaterally presented stimuli as coming only from the right (Mesulam, 1998). The presence of a stimulus on the right side appears sufficient to obliterate attention to a similar stimulus on the left side.

**Interhemispheric Interaction and Inhibition**

Kinsbourne (1987) proposed a theory of interhemispheric interaction and inhibition, describing neglect as an imbalance in brain activation. He suggested that each hemisphere is activated by its cognitive and perceptual function. Thus, the left hemisphere will be activated by language and the right by spatial tasks. The two hemispheres are normally in a state of mutually inhibitory balance. With injury, this balance is lost, and the intact hemisphere exerts unopposed inhibition on the injured hemisphere. Proponents of this theory believe that activation of the right hemisphere decreases left visual spatial neglect, whereas activation of the left hemisphere increases left visual spatial neglect (Heilman & Watson, 1978).

Heilman and Watson (1978) attempted to test this hypothesis by presenting persons with left neglect with six cancellation tasks. Three cancellation tasks involved spatial tasks thought to stimulate the right hemisphere (i.e., line cancellation). The remaining three tasks involved crossing out words, which was intended to stimulate the left hemisphere through the use of language. Study participants made significantly fewer errors with the line-cancellation tasks than with the word-cancellation tasks. The authors proposed that spatial tasks stimulated the right hemisphere, with a subsequent decrease in neglect symptoms. Conversely, the verbal tasks were thought to stimulate the left hemisphere, which led to an increase in neglect symptoms. The authors believed that these results lend some credibility to the interhemispheric inhibition theory.

Cermak et al. (1991) carried out a pilot study that was also designed to investigate this theory. Five study participants with left visual neglect were exposed to activities designed to stimulate the left hemisphere (alphabet stereognosis, crossword puzzle, comprehension test) and, on alternating days, to activities designed to stimulate the right hemisphere (form stereognosis, puzzles, classical music). After these interventions, the participants were assessed with the Schenkenberg Line Bisection Test to determine the degree of neglect symptoms. No significant differences were found in their performance between the two conditions (stimulation of right hemisphere vs. stimulation of left hemisphere). The authors cited the use of activities that could have activated both hemispheres and a fatigue factor as possible explanations for their results.

In summary, most of the theories related to the mechanisms underlying unilateral neglect point to the contribution of attention. The variations among theories point to the possibility that differences in neglect manifestation could at least partially be explained by differences in lesion sites. In a study of 69 persons with acute right hemisphere cerebrovascular accident, Stone, Halligan, Marshall, and Greenwood (1998) found unilateral neglect to be a highly heterogeneous condition. Thus, it would follow that a variety of treatment strategies would be necessary to deal with this heterogeneity. The theories described here provide a basis from which to develop treatment approaches and a framework for application (Herman, 1992).

**New Approaches to Treatment of Unilateral Spatial Neglect**

In the treatment of unilateral spatial neglect, there are two promising new treatment techniques that potentially could be incorporated with conventional treatment approaches. Several authors (Cooke, 1992; Herman, 1992; Lin, 1996) have provided detailed reviews of conventional occupational therapy treatment approaches with unilateral spatial neglect. This information, therefore, will not be repeated in this article.

Both new approaches involve restraining sensory input to the less affected side. One approach—constraint-induced therapy—was not specifically developed or tested for use with persons with neglect; however, it has potential implications for the treatment of unilateral neglect. The other approach—partial visual occlusion—is aimed at reducing visual stimulation to the less affected side. These approaches are described here in relation to current neglect theories and potential application to occupational therapy practice.

**Constraint-Induced Therapy**

Constraint-induced therapy (CIT) is a relatively new technique with potential application to the treatment of unilateral neglect. CIT was derived from basic animal research. Taub (1980) showed through somatosensory deafferentation research with monkeys that monkeys with unilateral forelimb deafferentation had a virtually useless extremity on the deafferented side. In contrast, monkeys with bilateral forelimb deafferentation continue to use both limbs extensively. Taub postulated that this difference in response to deafferentation could be due to learned helplessness that is based on the following mechanism: During the initial phase of spinal shock (after deafferentation), the animal loses considerable motor function. When motor function returns, the animal had already learned not to use its limb through failed attempts during the spinal shock phase. Taub termed the resultant persistent poor use of that limb learned nonuse. He employed various programs to attempt to train monkeys to overcome learned nonuse. Most of these programs involved shaping techniques (gradually increasing activity difficulty) to the deafferented forelimb,
restraint of the intact forelimb, or both. Having obtained promising results (increased use of the deafferented limb) with both techniques, Taub hypothesized that these techniques had potential application to the rehabilitation of various diagnostic groups, including persons who had experienced strokes.

Wolf, Lecraw, Barton, and Jann (1989) published the first study to investigate the systematic application of forced use to neurological patients. They defined forced use as “directing patient attention and effort toward the hemiparetic upper extremity to the exclusion of the uninvolved, contralateral limb” (p. 125). Wolf et al.’s study included 21 participants (4 with right hemisphere involvement, 17 with left hemisphere involvement) who met certain criteria of motor function of the affected side (i.e., the ability to initiate wrist and finger extension, demonstration of protective responses to imposed disequilibrium). The participants were required to wear a sling on their uninvolved upper extremity during all waking hours for a 2-week period. At 1-year follow-up, the participants showed significant improvements in 19 of the 21 measures, which included timed tasks and force measurements. The researchers did not find significant differences (regarding improvements noted) between participants with right and left hemisphere lesions.

Taub and Wolf (1997) carried out a pilot study of the effects of constraint-induced therapy on patients who were more than 1 year poststroke. Nine patients were randomly assigned to an experimental group (4 patients) and a control group (5 patients). The experimental group wore a resting hand splint and a sling on the nonhemiplegic upper extremity during waking hours for 12 consecutive days. During weekdays, they received 7 hours of functional task practice while wearing the sling. The control group received interventions that focused attention on the involved extremity but did not wear a sling or a splint. All participants received two clinical tests before and after their 12-day intervention period. One test consisted of several simple extremity movement tasks, with time and force measurements for each task. The other test involved more complex ADL, such as feeding and dressing tasks. The experimental group showed a mean performance time improvement of 38% on the extremity movement tasks and a 28% improvement with ADL. The control group showed no significant improvements. At 2-year follow-up, the functional gains of the experimental group had been maintained. Additionally, an activity log was used to measure functional use of the extremity in the home situation as related to ADL. The log showed a 97% increase in the number of activities the participants could perform after treatment and at 2-year follow-up. Some of the new activities reported included writing and brushing teeth.

Taub and Wolf (1997) also described other methods of constraint, such as the use of a glove on the unaffected extremity. In terms of posture and normalizing function, a glove appears to be a better choice than a sling. Patients who wore the glove, however, were found to need more verbal reinforcement to not use the unaffected extremity for unilateral tasks.

CIT theoretically has some implications for the treatment of neglect. It is conceivable that many persons with somatosensory neglect may indeed have learned nonuse of the affected extremity. Thus, they could benefit from this intervention.

In terms of neglect treatment, CIT may not be the therapy of choice for one-on-one therapeutic sessions. During these sessions, emphasis is usually placed on normalizing function. If CIT is used between therapy sessions, the client will be forced to use his or her affected extremity for some activities, which could assist in reducing neglect. As discussed earlier in this article, it has been shown that active movement of the affected extremity, especially in the affected hemispace, could reduce the manifestations of visual spatial neglect (Robertson & North, 1992, 1993).

Use of CIT may assist in reducing neglect and increasing independence with ADL. At this stage, it is still difficult to separate the CIT effects from the normal recovery process after a stroke.

In terms of the disengagement theory (Kinsbourne, 1987; Posner et al., 1984) reducing sensory input to the unaffected side could assist in improving spatial neglect symptoms on the affected side. Usefulness of CIT for the treatment of unilateral neglect awaits further research. Clients who could benefit from this type of therapy have some active movement of the involved upper extremity as well as insight into their limitations. A client who does not have insight will be reluctant to be constrained in this manner.

Partial Visual Occlusion

Several authors described the use of partial visual occlusion for the treatment of unilateral spatial neglect. In the literature, partial visual occlusion is achieved by either patching the nonneglected half field of the study participants’ glasses (Beis, Andre, Baumgarten, & Challier, 1999) or providing the participants with hemispatial sunglasses (Arai, Ohi, Sasaki, Nobuto, & Tanaka, 1997). These techniques are thought to force the person to use head turning and eye movements to scan into the neglected visual field.

Arai et al. (1997) selected 10 persons who displayed left-sided neglect in one or more of the following tasks: line bisection, line cancellation, and figure copying. The neglect was classified as mild, moderate, or severe with each task on the basis of amounts of deviation specified by the researchers. Study participants performed each task while wearing trial frames (adjusted to their levels of visual acuity) and hemispatial sunglasses. The darkened lenses allowed penetration of 8% visible light.
The researchers compared the participants’ performance on the paper-and-pencil tasks while wearing the hemispatial sunglasses to their performance without the sunglasses. Improvement or deterioration was defined as one or more grades of difference between the performances with and without the hemispatial sunglasses. In line bisection, 4 of the 10 participants showed improvements, 4 had no changes, and 2 showed deterioration in performance with the hemispatial sunglasses. With line cancellation, 3 improved, and 7 showed no change. Four improved with figure copying, and 6 remained unchanged.

The results could be accounted for by the difference in neglect mechanisms among the participants. Of note, most of these participants also had visual field deficits. A further drawback of this study is that it did not involve functional tasks, and severity of neglect was only measured before and during the intervention. Postintervention follow-up was not performed.

Arai et al. (1997) also reported on the functional use of the hemispatial sunglasses with one particular participant. The participant was 8 months poststroke and had difficulty with repeatedly walking into objects on his left side. He wore the hemispatial sunglasses for 1 week and stopped colliding with objects as soon as he started wearing them. This effect continued beyond the period of wearing the sunglasses, but the timing of the follow-up data is unclear.

Beis et al. (1999) performed a randomized study that compared functional outcomes of right half-field patching (7 participants) with right monocular patching (7 participants). The control group (8 participants) received no form of eye patching. All participants had a right cerebral vascular lesion and the presence of unilateral visual neglect as measured by Diller’s Test. The participants were randomly assigned to the three groups.

All participants underwent the same rehabilitation program with the rehabilitation department staff. They wore patched glasses throughout the day, with an average daily use of 12 hours. Evaluations were performed (without patches) at admission to the study, which coincided with admission to the rehabilitation facility, and again at 3 months after admission. The evaluation consisted of the Functional Independence Measure (FIM™) (Guide for the Uniform Data System for Medical Rehabilitation, 1993), Diller’s Test, a study of the visual field, and analysis of right eye movements. The FIM consists of 18 items that assess a range of ADL. Right eye movements were recorded by photococulography while participants read a series of letters aloud. Two measures were performed: the number of times the participant looked at predetermined reference zones in left and right hemispace and the time spent looking at letters in these two reference zones.

After 3 months, the three groups were compared, using nonparametric tests. Dependent variables were changes in total FIM score, score on Diller’s Test, and number of glances toward the right and left reference zone. Increases in total FIM score were found to be greatest in the participants wearing right half-field patches. Time spent looking at the left reference zone was longest in participants who wore patches, particularly those with right half-field patches.

The use of partial visual occlusion fits well with the disengagement theory, as does the use of CIT. Warren (1998) described persons with left neglect as having a predisposition toward either hypoattention to the left or hyperattention to the right. Persons who are predominantly hyperattentive to the right theoretically would benefit from the use of partial visual occlusion, which would decrease visual input from the right hemispace.

One of the benefits of partial visual occlusion is that it can be used during specific remedial training (e.g., visual scanning training) as well as during ADL. Once the glasses have been constructed, the training is simple to apply. The use of partial visual occlusion then can be incorporated into a home program. According to Beis et al. (1999), most of their study participants found the use of these glasses acceptable, although they may have felt uncomfortable at first. It should be noted that many persons experience a lack of motivation after a cerebrovascular accident (Pedretti, Smith, & Pendleton, 1996). This lack of motivation, which could be either organic or psychosocial in nature (Pedretti et al., 1996), could negatively affect a person’s compliance with any form of constraint, whether visual or motor.

Conclusion

Unilateral spatial neglect is a heterogeneous condition (Stone et al., 1998). Many techniques are available for occupational therapy treatment of this phenomenon. This article reviewed relevant literature and described two new treatment approaches with potential application to treatment of unilateral spatial neglect in the context of current neurophysiological theories. Development of a theoretical framework for applying these approaches and conventional techniques would be clinically useful. Further research on the use of various remedial techniques with patients with unilateral neglect is needed, especially regarding the long-term functional outcomes of these intervention strategies.

With increasingly shorter hospital and rehabilitation center stays, emphasis in health care will be on enabling patients to perform ADL as soon as possible, facilitating earlier discharge to the home environment. For patients with unilateral neglect, shorter stays will necessitate teaching immediate compensatory methods to perform ADL. Using such methods at the onset of treatment may lead to some
short-term task-specific gains. However, these methods might work against the principles of remediating the deficit by overemphasizing attention to the nonneglected side. A thorough understanding of the scientific basis of occupational therapy treatment for unilateral spatial neglect will help occupational therapists to articulate the need for intervention to third-party payers. Within the current constraints on treatment time, occupational therapists increasingly will consult with caregivers. Both CIT and partial visual occlusion are relatively easy to incorporate into a home program.

A framework for the treatment of unilateral neglect that relates to neurophysiological principles will assist with determining the most appropriate strategies for a specific patient. Further work is needed in not only theory development, but also the practical application of these theories to clinical practice. ▲

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